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CONCORDE NOISE-INDUCED BUILDING VIBRATIONS

SULLY PLANTATION - REPORT NO. 2

CHANTILLY, VIRGINIA

By

Staff-Langley Research Center

June 1976

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16. Abstract This is the second report on a series of planned studies to assess the noise-induced building vibrations associated with Concorde operations. The approach is to record the levels of induced vibrations and associated indoor/outdoor noise levels in selected homes, historic and other buildings near Dulles International Airport. Presented herein are representative data recorded at Sully Plantation, Chantilly, Virginia during the periods of May 20 through May 28, 1976, and June 14 through June 17, 1976. Recorded data provide relationships between the vibration levels of windows, walls, floors, and the noise associated with Concorde operations, other aircraft, and nonaircraft events. The results presented in this report are drawn from the combined May-June data base which is considerably larger than the May data base covered in the first report, NASA TM X-73919. The levels of window, wall and floor vibratory response resulting from Concorde operations are higher than the vibratory levels associated with conventional aircraft. Furthermore, the vibratory responses of the windows are considerably higher than those of the walls and floors. The window response is higher for aircraft than recorded nonaircraft events and exhibits a linear response relationship with the overall sound pressure level. For a given sound pressure level, the Concorde may cause more vibration than a conventional aircraft due to spectral or other differences. However, the responses associated with Concorde appear to be much more dependent upon sound pressure level than spectral or other characteristics of the noise.

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SULLY PLANTATION - REPORT NO. 2

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SUMMARY

This is the second report on a series of planned studies to assess the noise-induced building vibrations associated with Concorde operations. The approach is to record the levels of induced vibrations and associated indoor/outdoor noise levels in selected homes, historic and other buildings near Dulles International Airport. Presented herein are representative data recorded at Sully Plantation, Chantilly, Virginia during the periods of May 20 through May 28, 1976, and June 14 through June 17, 1976. Recorded data provide relationships between the vibration levels of windows, walls, floors, and the noise associated with Concorde operations, other aircraft, and nonaircraft events. The results presented in this report are drawn from the combined May-June data base which is considerably larger than the May data base covered in the first report, NASA TM X-73919. The levels of window, wall and floor vibratory response resulting from Concorde operations are higher than the vibratory levels associated with conventional aircraft. Furthermore, the vibratory responses of the windows are considerably higher than those of the walls and floors. The window response is higher for aircraft than recorded nonaircraft events and exhibits a linear response relationship with the overall sound pressure level. For a given sound pressure level, the Concorde may cause more vibration than a conventional aircraft due to spectral or other differences. However, the responses associated with Concorde appear to be much more dependent upon sound pressure level than spectral or other characteristics of the noise.

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INTRODUCTION

The vibratory response of historic and other buildings resulting from Concorde operations and the associated effects in terms of structural damage and human annoyance have been the subject of public concern (ref. 1). As a result of this concern, measurements of Concorde noise-induced building vibrations (ref. 2) are being conducted as part of the total Concorde assessment program. The first study in this phase of the assessment was carried out at Sully Plantation during the time period of May 20 through May 28, 1976, and reported in NASA TM X-73919 and (ref. 3). A second study was conducted at Sully Plantation from June 14 to June 17, 1976, to expand the data base. The results from the combined May-June data base are presented herein.

The approach to the assessment of Concorde noise-induced building vibrations involves the following steps: (1) the measurement of the vibratory response of windows, walls, and floors for selected historic (e.g., Sully Plantation), and other buildings; (2) the development of functional relationships ("signatures") between the vibration response of building elements and the range of outdoor and/or indoor noise levels associated with events of interest; (3) a comparison of the Concorde induced response with the response associated with other aircraft as well as common domestic events and/or criteria. The development of vibration/noise relationships or signatures (step 2) allows one to determine the response of the structure under study or a similar structure to any (similar) noise level of interest. This procedure reduces the reliance on maximum response levels and the associated statistical difficulty resulting from small sample sizes. Also the precise location of the noise source is not essential to this approach.

This report, which is the second in a series of reports, includes a brief overview of the tests conducted at Sully Plantation including data acquisition and reduction schemes, a log of the recorded events, and results. Results are presented in terms of the levels of vibration and noise associated with Concorde, other aircraft and nonaircraft events, the vibration-noise relationships or signatures (for the window) associated with the aircraft, and comparisons of Concorde induced response with other aircraft and nonaircraft events.

TEST SITE DESCRIPTION

Location

Figure 1 shows the location of Sully Plantation adjacent to Sully Road (Virginia State Route 28) 1.2 kilometers north of U.S. Route 50 in Chantilly, Virginia. The Plantation is 6.4 kilometers south of the Dulles Airport access road and approximately 2.2 kilometers south-southeast from the end of Dulles Airport Runway 19L.

Structural Details

Figure 2 is a photograph of the east elevation of Sully Plantation showing an Air France Concorde departing from runway 19L. As described in reference 4, the building is a two and one-half story central section flanked by asymmetrical one and one-half story gabled wings. Its foundation of red sandstone, averaging almost 60 cm in thickness, support walls which are sheathed by clapboards that cover a heavy mortise-and-tenon framing. The walls of the earliest portion of the house are insulated by means of the common 18th century "nogging" (filled with brick). Photographs showing structural details of the wall are presented in reference 3. Random width pine flooring attached directly to floor joists is used throughout the house (no subfloor). Windows are generally the 12 over 12 sashing type with some being 9 over 9, 6 over 9, and 6 over 6. Of the 324 window panes at Sully, half are original and a typical pane measures 20.3 cm by 25.4 cm and varies from 0.16 cm to 0.32 cm in thickness. All of the panes have been covered with transparent plastic Scotch-tint film to aid in reflecting sunlight.

The first floor of Sully contains three major rooms in addition to the main entrance hallway. The upstairs has two spacious bedrooms, a large chamber, and a small lodging room.

Figure 3 shows a plan view of the first floor of Sully Plantation including test instrumentation locations. In the May test, the instrumentation systems were located in the parlor and south drawing room; in the June test only the north parlor was instrumented. The instrument systems consisted of three accelerometers and one microphone for each room. Installation of the instruments is shown in figures 4 through 6. Microphones were located outside of the building as shown in the figure.

DATA LOG

Data at the Sully Plantation test site were recorded during the period May 20 through May 28, 1976, and June 14 through June 17, 1976. Table I is a chronological listing of events during the May time period and Table II is a listing for the June tests. A total of 169 events were measured which included not only aircraft operations and room calibrations but typical house occurrences such as visiting tour groups, a vacuum cleaner, chair falling, etc. A summary of recorded events for both test periods is presented in Table III.

DATA ACQUISITION AND PROCEDURE

Instrumentation

The details of the instrumentation system deployed during the May tests are described in reference 3. The second series of measurements at Sully Plantation, June 1976, was conducted using a mobile laboratory containing both an analog acquisition system and an on-line digital processing system. Data were obtained only from the parlor or north room during the June test and consisted of acoustic measurements of interior and exterior sound pressure levels as well as vibration levels of the floor, exterior wall, and window. Conventional Bruel and Kjaer equipment was used for the sound measurements and piezoelectric crystal accelerometers, employing in-house developed signal conditioning, were used for the vibration measurements. All data were recorded on analog FM tape for further analysis. On-line analog x-y plots of window vibration response versus outside sound pressure level were obtained for many of the events. The primary system used for on-line acquisition consisted of a General Radio 1926 true rms log voltmeter which provided overall or magnitude values each one-half second for the five information channels. A Hewlett-Packard 21M20 digital computer was then used to assemble these data into tabulations of the time history values for line printing and for "Calcomp" plots of the acoustic time histories as well as plots of selected acceleration levels as a function of outside sound pressure levels. Figure 7 is a block diagram of the instrument system used in this test.

Frequency Response and Calibration Procedures

In addition to extensive pretest documentation of frequency response, deviation linearities, gain accuracies and dynamic range, daily calibrations consisted of: tape recorder sensitivity (deviation) checks, pink noise (voltage) insertion in the microphone channels, one-half volt sine wave reference voltage insertion into accelerometer channels, and 250 Hz pistonphone acoustic calibration of the microphone systems for pretest and posttest as a minimum and more frequently, time permitting. Frequency response of the acoustic channels is nominally ± 1 dB over the range from approximately 5 Hz to 10 kHz and ± 1/2 dB over the range from approximately 3 Hz to in excess of 3 kHz for the accelerometer channels.

Test Procedures and Communications

Visual observation of airport activity via an opening in the roof of the house, monitoring tower communications with aircraft in the area, and/or spotters located some distance from the plantation were used to identify aircraft operations as well as to control and coordinate data acquisition. Time code was recorded to provide a common time for use in later analysis. Because the computer required 5 to 10 minutes to completely analyze each flyover, those events which were not obtained in real time with the computer were readily obtained from tape playback.

Reference Acoustic Source

To provide a controlled acoustic input into each of the rooms, an Altec Model 9844A, playback/monitor speaker system having a frequency response extending from approximately 50 Hz to 15 kHz was used as the transducer. The speaker system contains two 12 inch (30.48 cm) speakers and a high-frequency horn. USASI shaped noise spectra at several acoustic levels (as monitored on a hand-held sound level meter) were impressed on the wall from approximately 6 feet (1.83 meters) away and data recordings made. Some sine wave testing was also performed. Figure 8 shows this system in the parlor (north room) essentially as it was positioned for the calibration tests.

PRESENTATION OF RESULTS

The data obtained during the May test period indicated that the maximum vibratory response resulting from aircraft operations occurred in the north room (parlor) which faces the Dulles runways and was associated with aircraft takeoff operations. Furthermore, the maximum aircraft-induced vibrations were associated with Concorde operations, however, there were too few Concorde operations to compare (with confidence) Concorde with other aircraft. Thus, a second series of tests was conducted during June 1976 to extend the data base. Data were recorded in the north room only during the June series and were limited to takeoff operations.

Levels of Vibration

The maximum levels of vibration recorded on the windows, walls and floor for the various events are shown in Tables IV and V and figures 9 through 11 along with the associated overall sound pressure levels. In general, each bar contains the maximum values recorded for several events. The Concorde induced response is seen to exceed the response due to other aircraft and nonaircraft events for the window. The wall and floor, however, exhibit comparable or greater response for nonaircraft events. The responses of the floor and wall are considerably lower than the window response which may be due to the atypical construction such as "nogging" and large floor joists.

Signatures

In order to quantitatively assess the relationships between aircraft noise levels and the corresponding levels of vibration induced in the window, response signatures (plots of window acceleration versus sound pressure level) were made for each flyover event. A least squares regression analysis was performed for each signature to calculate the slope and ordinate intercept for the best straight line fitting the response signature data. A correlation coefficient was also calculated for each signature to determine how well the best straight line fit the data. The correlation coefficient can range from zero (no correlation) to one (perfect correlation). Response signatures for which the correlation coefficient exceeded an arbitrarily selected threshold of 0.6 were retained for further quantitative analysis. Data for several events were then grouped by aircraft type and the composite response signatures displayed in figures 12 through 16 were generated. Listed by aircraft type in Table VI are the slopes, ordinate intercepts, and correlation coefficients for each of the events used to compile the composite response signatures in figures 12 through 16. Also listed in Table VI are the straight line parameters for these composite signatures. A composite response signature based on all non-Concorde flights was also generated (figure 17) for comparison with the Concorde signature (figure 12).

Comparative Response

It has been suggested that, for a given sound pressure level, vibration induced in structures by Concorde may be different than vibration levels (ref. 5) induced by conventional jet transports. To investigate this question, curves were generated in which, for a given sound pressure level, Concorde induced vibration levels were divided by the vibration levels caused by conventional aircraft. (The vibration levels were determined from the regression curves in figures 12 through 17.) These "response ratios" were then plotted (figure 18) as a function of sound pressure level. In figure 18a, response ratios for a number of individual aircraft are presented. Figure 18b represents the composite response ratio curve for all conventional aircraft compared to Concorde, based on the regression curves of figures 12 and 17. These response ratios suggest that for sound levels of about 90 to 100 dB and below (the range of most conventional aircraft operations near Sully), the Concorde generally induced lower vibration levels in the north parlor window than did conventional jet transports. At higher sound levels, the Concorde is apparently more efficient in exciting a window response; however, this last conclusion is necessarily based on an extrapolation of conventional jet noise to higher levels and must therefore be construed as tentative. The DC-8 represents one exception to the general trend; it consistently generated higher vibration levels in the window than the Concorde for a given sound level. It should be noted that, because of the higher sound levels associated with Concorde operations, maximum absolute vibration levels induced in the window by Concorde are generally higher than the peak vibration levels induced by conventional aircraft.

CONCLUDING REMARKS

The following conclusions are based on building vibratory response measurements at Sully Plantation for 128 aircraft flyovers (7 Concorde) and 21 household or other activities including door slams, radio, vacuum cleaner, traffic noise, etc. Maximum response to aircraft was recorded in a north room facing the runways and was associated with takeoff operations. The following comments apply to the north room during the May-June 1976 test series:

1. The Concorde noise-induced vibration levels of the windows, walls and floors are higher by a factor of 2 or more than the levels resulting from conventional aircraft operations.

2. The window response levels associated with aircraft operations (0.432 g_{rms} maximum) are higher by a factor of 2 or more than the wall and floor response possibly due to the atypical heavy construction of the walls and floors at Sully.

3. The window response is higher for aircraft than nonaircraft events, the wall response to aircraft and nonaircraft are comparable, and the nonaircraft events result in higher floor response.

4. At a given sound pressure level, the window generally responds somewhat differently to different aircraft, however, these aircraft-to-aircraft variations are small compared to the range of vibration levels encountered for a given flyover. This result suggests that the absolute vibration levels induced in the window during a flyover depend more on the overall sound pressure level associated with that flyover than on any other characteristics of the source.

5. At a given sound pressure level, the Concorde may cause slightly more window vibration response than conventional aircraft when the noise levels are

high and lower relative response when the noise levels are low. The response ratio calculated from measured data (Concorde g/aircraft g) ranged from a maximum of 2 at high noise levels to about 0.5 at low levels.

6. The window response exhibits a linear relationship with overall sound pressure level. The responses of the walls and floor are not of sufficient range to develop a noise-vibration relationship. This latter fact suggests that more typical building structures be examined to determine such relationships.

REFERENCES

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5. Department of Transportation, United States of America: The Secretary's Decision on Concorde Supersonic Transport. Washington, DC, Feb. 4, 1976.

TABLE I.- OPERATIONS LOG MAY 1976

EVENT NO.	DATE	TIME		RUNWAY	AIRCRAFT TYPE	AIRCRAFT OPERATION	BUILDING OPERATION		REMARKS
		A.M.	P.M.				DRAWING ROOM	PARLOR	
101	5-20-76		4:55	IR	DC-8	Landing	-	-	
102	5-21-76	8:45		-	-	-	90 dB Cal.		USASI Noise
103	5-21-76	8:50		-	-	-	80 dB Cal.		USASI Noise
10′	5-21-76	8:55		-	-	-	70 dB Cal.		USASI Noise
105	5-21-76	9:00		-	-	-	Ambient Cal.		
106	5-21-76	9:40		-	-	-	90 dB Cal.		USASI Noise
107	5-21-76	10:10		-	-	-	80 dB Cal.		USASI Noise
108	5-21-76	10:20		-	-	-	Ambient Cal.		
109	5-21-76	11:00		IR	DC-8	Landing	-	-	
110	5-21-76	11:34		IR	727	Landing	-	-	
111	5-21-76	11:36		19L	727	Takeoff	-	-	
112	5-21-76	11:37		19L	707	Takeoff	-	-	
113	5-21-76	11:44		19L	DC-8	Takeoff	-	-	
114	5-21-76	11:52		-	Helicopter	Overhead	-	-	
115	5-21-76		12:06	19L	727	Takeoff	-	-	
116	5-21-76		1:08	19L	DC-9	Takeoff	-	-	
117	5-21-76		3:13	IR	DC-9	Landing	-	-	
118	5-22-76	-	-	IR	Gen. Av. Jet	Landing	-	-	
119	5-22-76	10:23		IR	727	Landing	-	-	
120	5-22-76	10:25		IR	R-5 Navy	Landing	-	-	

TABLE I (Cont'd).- OPERATIONS LOG MAY 1976

EVENT No.	DATE	TIME		RUNWAY	AIRCRAFT TYPE	AIRCRAFT OPERATION	BUILDING OPERATION		REMARKS
		A.M.	P.M.				DRAWING ROOM	PARLOR	
121	5-22-76	10:50		IR	707	Landing	-	-	
122	5-22-76	10:58		IR	727	Landing	-	-	
123	5-22-76	11:10		IR	DC-8	Landing	-	-	
124	5-22-76	11:50		IR	DC-9	Landing	-	-	
125	5-22-76		12:20	IR	727	Landing	-	-	
126	5-24-76	9:12		IR	747	Landing	-	-	
127	5-24-76	9:25		IR	747	Landing	-	-	
128	5-24-76	9:59		IR	747	Landing	-	-	
129	5-24-76	10:50		IR	727	Landing	-	-	
130	5-24-76	10:56		IR	707	Landing	-	-	
131	5-24-76	11:10		IR	727	Landing	-	-	
132	5-24-76	11:50		IR	Concorde	Landing	-	-	
133	5-24-76	11:53		IR	Concorde	Landing	-	-	
134	5-25-76	9:04		IR	707	Landing	-	-	
135	5-25-76	9:16		IR	727	Landing	-	-	
136	5-25-76	-	-	IR	707	Touch and Go	-	-	
137	5-25-76	10:16		IR	707	Touch and Go	-	-	
138	5-25-76	10:19		IR	727	Landing	-	-	
139	5-25-76	10:38		IR	707	Touch and Go	-	-	
140	5-25-76	10:50		IR	727	Landing	-	-	

TABLE I (Cont'd).- OPERATIONS LOG MAY 1976

EVENT No.	DATE	TI A.M.	TI P.M.	RUNWAY	AIRCRAFT TYPE	AIRCRAFT OPERATION	BUILDING OPERATION DRAWING ROOM	BUILDING OPERATION PARLOR	REMARKS
141	5-25-76		12:05	19L	Concorde	Takeoff	-	-	
142	5-25-76		12:59	19R	Concorde	Takeoff	-	-	
143	5-25-76		3:10	19L	727	Takeoff	-	-	
144	5-25-76		3:33	19L	BAC-111	Takeoff	-	-	
145	5-25-76		3:45	19L	BAC-111	Takeoff	-	-	
146	5-25-76		3:55	19L	BAC-111	Takeoff	-	-	
147	5-26-76	8:56		19L	727	Takeoff	-	-	
148	5-26-76	9:13		19L	707	Takeoff	-	-	
149	5-26-76	9:23		19L	DC-8	Takeoff	-	-	
150	5-26-76	9:30		19L	707	Takeoff	-	-	
151	5-26-76	9:48		19L	727	Takeoff	-	-	
152	5-26-76	10:03		19L	727	Takeoff	-	-	
153	5-26-76	10:13		19L	747	Takeoff	-	-	
154	5-26-76	11:09		19L	BAC-111 or DC-9	Takeoff	-	-	
155	5-26-76	11:11		19L	727	Takeoff	-	-	
156	5-26-76		1:25	-	-		Tour Group 20-30 People		Adults
157	5-26-76		1:29	-	-	-	Tour Group 20-30 People		Adults
158	5-26-76		1:32	-	-	-		Tour Group 4-6 People	Adults
159	5-26-76		1:40	-	-	-	-	Door Slams	
160	5-26-76		1:42	-	-	-	-	Door Slams	

TABLE I (Cont'd).- OPERATIONS LOG MAY 1976

EVENT No.	DATE	TIME A.M.	TIME P.M.	RUNWAY	AIRCRAFT TYPE	AIRCRAFT OPERATION	BUILDING OPERATION DRAWING ROOM	BUILDING OPERATION PARLOR	REMARKS
161	5-26-76		1:43	-	-	-	Chair Falling	-	
162	5-26-76		1:55	-	-	-	Chair Falling	-	
163	5-26-76		2:04	-	-	-	Radio Playing	-	
164	5-26-76		2:07	-	-	-		Radio Playing	
165	5-26-76		2:18	-	-	-	Ambient Cal.	Ambient Cal.	
166	5-26-76		2:23	-	-	-	-	Vacuum Cleaner	
167	5-27-76	9:38		-	-	-	-	[illegible]5 dB Cal.	USASI Noise
168	5-27-76	9:47		-	-	-	-	90 dB Cal.	USASI Noise
169	5-27-76	9:57		-	-	-	-	95 dB Cal.	USASI Noise
170	5-27-76	10:06		-	-	-	-	100 dB Cal.	USASI Noise
171	5-27-76	10:11		-	-	-	-	20-100 Hz Cal.	Sine Wave
172	5-27-76	10:15		-	-	-	-	100-1 kHz Cal.	Sine Wave
173	5-27-76	10:21		-	-	-	-	100-200 Hz Cal.	Sine Wave
174	5-27-76	10:32		-	-	-	Tour Group 20-30 People	-	Children
175	5-27-76	10:45		-	-	-	-	Tour Group 4-6 People	Children

TABLE I (Concluded).- OPERATIONS LOG MAY 1976

EVENT No.	DATE	TIME		RUNWAY	AIRCRAFT TYPE	AIRCRAFT OPERATION	BUILDING OPERATION		REMARKS
		A.M.	P.M.				DRAWING ROOM	PARLOR	
176	5-27-76			1L	Concorde	Takeoff	-	-	
177	5-27-76		1:31	1R	747	Landing	-	-	
178	5-27-76		20	-	-	-	85 dB Cal.	-	USASI Noise
179	5-27-76		3:[illegible]2	-	-	-	90 dB Cal.		USASI Noise
180	5-27-76		3:24	-	-	-	95 dB Cal.	-	USASI Noise
181	5-27-76		3:28	-	-	-	100 dB Cal.	-	USASI Noise
182	5-27-76		3:30	-	-	-	20-100 Hz Cal.	-	Sine Wave
183	5-27-76		3:33	-	-	-	100-1 kHz Cal.	-	Sine Wave
184	5-27-76		4:01	-	-	-	-	-	Cement Truck on RT 28
185	5-27-76		4:05	-	-	-	-	-	Cement Truck on RT 28
186	5-27-76		4:06	-	-	-	-	-	Panel Truck on RT 28
187	5-27-76		4:08	-	-	-	-	-	Panel Truck on RT 28
188	5-27-76		4:11	-	-	-	-	-	Tank Truck on RT 28
189	5-27-76		4:13	-	-	-	-	-	Two semitrucks on RT 28
190	5-28-76		-	19L	707	Takeoff	-	-	
191	5-28-76		-	19L	C-130	Takeoff	-	-	
192	5-28-76		-	19L	747	Takeoff	-	-	
193	5-28-76		-	19L	707	Takeoff	-	-	

TABLE II.- OPERATIONS LOG JUNE 1976

EVENT NO.	DATE	TIME		RUNWAY	AIRCRAFT TYPE	AIRCRAFT OPERATION	BUILDING OPERATION		REMARKS
		A.M.	P.M.				DRAWING ROOM	PARLOR	
194			VOID						
195	6-14-76	9:12		19L	707	Takeoff	-	-	-
196	6-14-76	9:22		19L	DC-8	Takeoff	-	-	-
197	6-14-76	9:29		19L	707	Takeoff	-	-	-
198	6-14-76	9:48		19L	727	Takeoff	-	-	-
199	6-14-76	10:04		1SL	727	Takeoff	-	-	-
200	6-14-76	10:24		19L	747	Takeoff	-	-	-
201	6-14-76	10:26		19L	707	Takeoff	-	-	-
202	6-14-76	10:35		19L	707	Takeoff	-	-	-
203	6-14-76	11:08		19L	727	Takeoff	-	-	-
204	6-14-76	11:25		19L	727	Takeoff	-	-	-
205	6-14-76	11:36		19L	727	Takeoff	-	-	-
206	6-14-76	11:53		19L	DC-10	Takeoff	-	-	-
207	6-14-76	12:13		19L	DC-8	Takeoff	-	-	-
208	6-14-76	12:15		19L	727	Takeoff	-	-	-
209	6-14-76	12:25		19L	707	Takeoff	-	-	-
210	6-14-76		1:01	19L	Concorde	Takeoff	-	-	-
211	6-14-76		3:14	19L	727	Takeoff	-	-	-
212	6-14-76		3:47	19L	727	Takeoff	-	-	-

TABLE II (Cont'd).- OPERATIONS LOG JUNE 1976

EVENT NO.	DATE	TIME		RUNWAY	AIRCRAFT TYPE	AIRCRAFT OPERATION	BUILDING OPERATION		REMARKS
		A.M.	P.M.				DRAWING ROOM	PARLOR	
213	6-14-76		3:57	19L	747	Takeoff	-	-	-
214	6-14-76		4:04	19L	DC-8	Takeoff	-	-	-
215	6-14-76		4:06	19L	DC-9	Takeoff	-	-	-
216	6-14-76		4:15	19L	727	Takeoff	-	-	-
217	6-14-76		4:55		727	Takeoff	-	-	-
218	6-14-76		5:01	19L	DC-9	Takeoff	-	-	-
219	6-14-76		5:03	19L	707	Takeoff	-	-	-
220	6-14-76		5:23	19L	707	Takeoff	-	-	-
221	6-14-76		5:24	19L	707	Takeoff	-	-	-
222	6-14-76		5:28	19L	L-1011	Takeoff	-	-	-
223	6-14-76		5:35	19L	DC-8	Takeoff	-	-	-
224	6-14-76		5:52	19L	DC-10	Takeoff	-	-	-
225	6-14-76		5:59	19L	707	Takeoff	-	-	-
226	6-14-76		6:02	19L	707	Takeoff	-	-	-
227	6-14-76		6:10	19L	727	Takeoff	-	-	-
228	6-14-76		6:12	19L	DC-10	Takeoff	-	-	-
229	6-14-76		6:14	19L	707	Takeoff	-	-	-
230	6-14-76		6:16	19L	737	Takeoff	-	-	-
231	6-14-76		6:18	19L	DC-8	Takeoff	-	-	-

TABLE II (Cont'd).- OPERATIONS LOG JUNE 1976

EVENT NO.	DATE	TIME		RUNWAY	AIRCRAFT TYPE	AIRCRAFT OPERATION	BUILDING OPERATION		REMARKS
		A.M.	P.M.				DRAWING ROOM	PARLOR	
232	6-14-76		6:24	19L	707	Takeoff	-	-	-
233	6-14-76		6:38	19L	DC-9	Takeoff	-	-	-
234	6-14-76		6:37	19L	747	Takeoff	-	-	-
235	6-14-76		6:45	19L	707	Takeoff	-	-	-
236	6-14-76		6:48	19L	727	Takeoff	-	-	-
237	6-14-76		6:58	19L	707	Takeoff	-	-	-
238	6-14-76		7:02	19L	727	Takeoff	-	-	-
239	6-14-76		7:04	19L	727	Takeoff	-	-	-
240	6-15-76	10:14		19L	747	Takeoff	-	-	-
241	6-15-76	11:32		19L	727	Takeoff	-	-	-
242	6-15-76		12:07	19L	DC-8	Takeoff	-	-	-
243	6-15-76		12:23	19L	DC-9	Takeoff	-	-	-
244	6-15-76		12:29	19L	DC-10	Takeoff	-	-	-
245	6-15-76		12:33	19L	DC-8	Takeoff	-	-	-
246	6-15-76		3:51	19L	747	Takeoff	-	-	-
247	6-15-76		4:05	19L	DC-8	Takeoff	-	-	-
248	6-15-76		5:24	19L	DC-9	Takeoff	-	-	-
249	6-15-76		5:37	19L	L-1011	Takeoff	-	-	-
250	6-15-76		5:47	19L	DC-8	Takeoff	-	-	-
251	6-15-67		6:02	19L	707	Takeoff	-	-	-

TABLE II (Cont'd).- OPERATIONS LOG JUNE 1976

EVENT NO.	DATE	TIME		RUNWAY	AIRCRAFT TYPE	AIRCRAFT OPERATION	BUILDING OPERATION		REMARKS
		A.M.	P.M.				DRAWING ROOM	PARLOR	
252	6-15-76		6:05	19L	DC-10	Takeoff	-	-	-
253	6-15-76		6:14	19L	DC-10	Takeoff	-	-	-
254	6-15-76		6:16	19L	707	Takeoff	-	-	-
255	6-15-76		6:20	19L	DC-8	Takeoff	-	-	-
256	6-15-76		6:26	19L	General Aviation Jet	Takeoff	-	-	-
257	6-15-76		6:29	19L	737	Takeoff	-	-	-
258	6-15-76		6:39	19L	747	Takeoff	-	-	-
259	6-17-76	11:13		19L	727	Takeoff	-	-	-
260	6-17-76	11:23		19L	727	Takeoff	-	-	-
261	6-17-76	11:32		19L	727	Takeoff	-	-	-
262	6-17-76	11:44		19L	707	Takeoff	-	-	-
263	6-17-76	11:52		19L	DC-10	Takeoff	-	-	-
264	6-17-76		12:11	19L	DC-8	Takeoff	-	-	-
265	6-17-76		12:26	19L	DC-9	Takeoff	-	-	-
266	6-17-76		1:01	19L	Concorde	Takeoff	-	-	-

TABLE II (Concluded).- OPERATIONS LOG JUNE 1976

EVENT NO.	DATE	TIME		RUNWAY	AIRCRAFT TYPE	AIRCRAFT OPERATION	BUILDING OPERATION		REMARKS
		A.M.	P.M.				DRAWING ROOM	PARLOR	
267	6-17-76		1:34	-	-	-	-	Dropped book on floor	From 4 feet high
268	6-17-76		1:35	-	-	-	-	Dropped book on floor	From 3 feet high
269	6-17-76		1:37	-	-	-	-	Stepped from chair onto floor	180 # person
270	6-17-76		1:38	-	-	-	-	Stepped from chair onto floor	180 # person

TABLE III.- SUMMARY OF RECORDED EVENTS

AIRCRAFT EVENTS

	May 20-28, 1976		June 14-17, 1976	
	TAKEOFF	LANDING	TAKEOFF	LANDING
707	5	6	17	0
727	7	9	18	0
737	0	0	2	0
747	2	4	6	0
DC-8	2	3	11	0
DC-9	2	2	6	0
DC-10	0	0	7	0
BAC-111	3	0	0	0
L-1011	0	0	2	0
Helicopter	1	0	0	0
General Aviation Jet	2	1	1	0
R-5 Navy Propeller	0	1	0	0
C-130 Propeller	1	0	0	0
Concorde	3	2	2	0
TOTALS	28	28	72	0

SPECIAL EVENTS

	May 20-28, 1976	June 14-17, 1976
Tour Groups	5	0
Door Slams	1	0
Chair Step	0	2
Chair Drop	2	0
Book Drop	0	2
Radio Playing	2	0
Vacuum Cleaner On	1	0
Trucks Passing By	6	0
TOTALS	17	4

Calibrates - 20

Total Events - 169

TABLE IV.- MAXIMUM VALUES OF AIRCRAFT TAKEOFF

VIBRATION RESPONSE MEASUREMENTS

Aircraft	Event	Exterior Overall SPL, dB*	OA Acceleration, g_{rms} Window	Wall	Floor
Concorde	141	106.1	.432	.048	.024
	142	81.1	.019	.010	.008
	176	85.3	.039	.012	.014
	210	107.7	.335	.038	.166
	266	106.6	.351	.047	.077
DC-8	113	95.2	.090	.013	.017
	207	92.6	.105	.020	.046
	214	86.3	.055	.018	.021
	223	95.1	.182	.020	.018
	231	95.4	.209	.021	.025
	242	99.5	.229	.023	.016
	247	84.8	.052	.017	.016
	250	98.1	.138	.018	.020
	255	98.2	.155	.018	.018
	264	93.5	.091	.025	.030
B-707	112	95.0	.044	.014	.021
	149	100.2	.160	.028	.021
	195	88.0	.076	.015	.019
	197	94.4	.106	.016	.031
	201	91.5	.078	.015	.024
	202	90.6	.082	.015	.027
	209	94.0	.130	.020	.046
	219	88.0	.045	.019	.018
	220	86.7	.064	.018	.015
	221	80.5	.032	.017	.018
	225	86.7	.075	.022	.019
	226	88.0	.079	.019	.019
	229	88.5	.063	.018	.017
	232	91.0	.052	.020	.017
	235	92.2	.108	.020	.022
	237	98.8	.145	.021	.024
	251	90.9	.064	.016	.014
	254	103.4	.119	.020	.018
B-727	115	86.2	.120	.025	.023
	151	90.3	.078	.019	.017
	152	82.2	.041	.019	.018
	198	88.0	.064	.015	.022

*SPL values correspond to max vibration level and do not necessarily represent max recorded SPL values.

TABLE IV (Concluded).- MAXIMUM VALUES OF AIRCRAFT TAKEOFF

VIBRATION RESPONSE MEASUREMENTS

Aircraft	Event	Exterior Overall SPL, dB*	OA Acceleration, g_{rms} Window	Wall	Floor
B-727 (Cont'd)	203	87.3	.068	.016	.028
	205	83.3	.060	.016	.016
	211	86.4	.067	.019	.035
	212	95.1	.092	.021	.026
	216	88.0	.072	.022	.026
	217	87.3	.076	.018	.034
	227	88.8	.093	.025	.019
	236	89.0	.078	.019	.017
	238	88.0	.058	.016	.019
	239	90.9	.073	.019	.016
	241	94.8	.072	.018	.020
	259	87.9	.038	.022	.026
	260	90.1	.063	.023	.027
	261	93.2	.062	.026	.030
L-1011	222	88.5	.064	.018	.016
	249	87.6	.046	.018	.016
DC-9	116	86.1	.037	.013	.013
	215	83.6	.046	.017	.017
	218	83.2	.035	.020	.018
	233	82.9	.057	.020	.017
	243	82.3	.035	.018	.018
	248	85.0	.036	.016	.015
	265	84.4	.045	.016	.016
DC-10	206	83.4	.037	.016	.017
	224	84.4	.046	.016	.016
	228	85.1	.044	.023	.019
	244	83.7	.034	.018	.018
	252	86.5	.036	.014	.014
	253	80.2	.03[illegible]	.016	.015
B-747	153	88.8	.051	.022	.020
	192	92.0	.091	.013	.014
	200	87.1	.052	.016	.017
	213	85.7	.046	.019	.018
	234	86.5	.054	.017	.017
	240	92.6	.089	.020	.019
	246	85.9	.054	.016	.016
	258	83.8	.043	.013	.013

*SPL values correspond to max vibration level and do not necessarily represent max recorded SPL values.

TABLE V.- MAXIMUM VALUES OF VIBRATION RESPONSE

DATA DUE TO SPECIAL EVENTS

Activity	Event	OA SPL, dB*		OA Acceleration, g_{rms}		
		Ext.	Int.	Window	Wall	Floor
Tour Group	175	NA	73.3	.013	.013	.068
Vacuum Cleaner	166	NA	96.3	.105	.025	.065
USASI Noise	167	NA	85.0	.025	.015	.018
USASI Noise	168	NA	91.0	.042	.016	.023
USASI Noise	169	NA	96.0	.084	.020	.036
USASI Noise	170	NA	102.0	.143	.029	.064
Book Drop**	268	NA	NA	----	.18	3.8
Step From Chair to Floor**	269	NA	NA	----	<.04	1.0
Traffic	186	70.8	---	.013	.013	.013

*SPL values correspond to max vibration level and do not necessarily represent max recorded SPL values.
**Peak acceleration level, g's.

TABLE VI - RESPONSE SIGNATURE PARAMETERS

A. Concorde

Event	Slope	Y-Int.	Coef.	No. Pts.
266	.851	18.36	.974	19
141	1.31	-27.3	.965	30
142	.594	35.36	.384	19
176	.658	34.06	.607	25
210	.969	4.601	.862	22
Composite	.971	5.454	.915	115

B. DC-8

Event	Slope	Y-Int.	Coef.	No. Pts.
207	.963	8.582	.806	38
214	.9[illegible]1	8.059	.684	30
223	1.12	-4.18	.804	30
264	1.00	4.372	.831	33
231	1.11	-4.18	.863	39
242	1.03	.8813	.937	33
2[illegible]	1.00	3.676	.777	37
1[illegible]	1.12	-5.07	.954	29
149	.851	17.48	.918	40
255	1.25	-18.4	.915	30
Composite	.982	6.63[illegible]	.841	339

C. 707

Event	Slope	Y-Int.	Coef.	No. Pts.
195	.802	23.[illegible]	.624	23
197	.774	25.68	.766	27
201	.813	22.15	.725	18
202	.889	15.33	.757	27
209	.910	12.64	.707	27
219	.720	29.15	.703	24
225	.986	8.522	.616	13
226	.740	27.88	.794	31
229	.911	15.05	.647	20
235	.963	9.353	.827	19
237	.939	11.21	.864	24
251	.817	21.46	.717	20
112	1.09	-5.36	.885	24
150	.899	14.32	.892	15
190	.939	9.776	.929	22
254	.764	24.50	.950	22
Composite	.778	24.78	.768	356

D. 727

Event	Slope	Y-Int.	Coef.	No. Pts.
205	.701	31.68	.666	19
211	.917	14.04	.638	17
212	.596	40.58	.710	27
236	1.09	-1.14	.865	17
241	.428	54.44	.695	21
260	.586	41.42	.823	17
261	.522	47.29	.846	19
151	.796	23.66	.678	25
Composite	.596	40.49	.685	162

E. 747

Event	Slope	Y-Int.	Coef.	No. Pts.
213	1.17	-7.90	.969	5
192	.726	27.[illegible]	.766	23
240	.732	[illegible]	.800	31
246	.878	16.[illegible]	.650	26
200	1.04	2.088	.774	[illegible]
Composite	.677	32.[illegible]5		[illegible]

F. CTOL

Event	Slope	Y-Int.	Coef.	No. Pts.
Composite	.821	21.0[illegible]		954

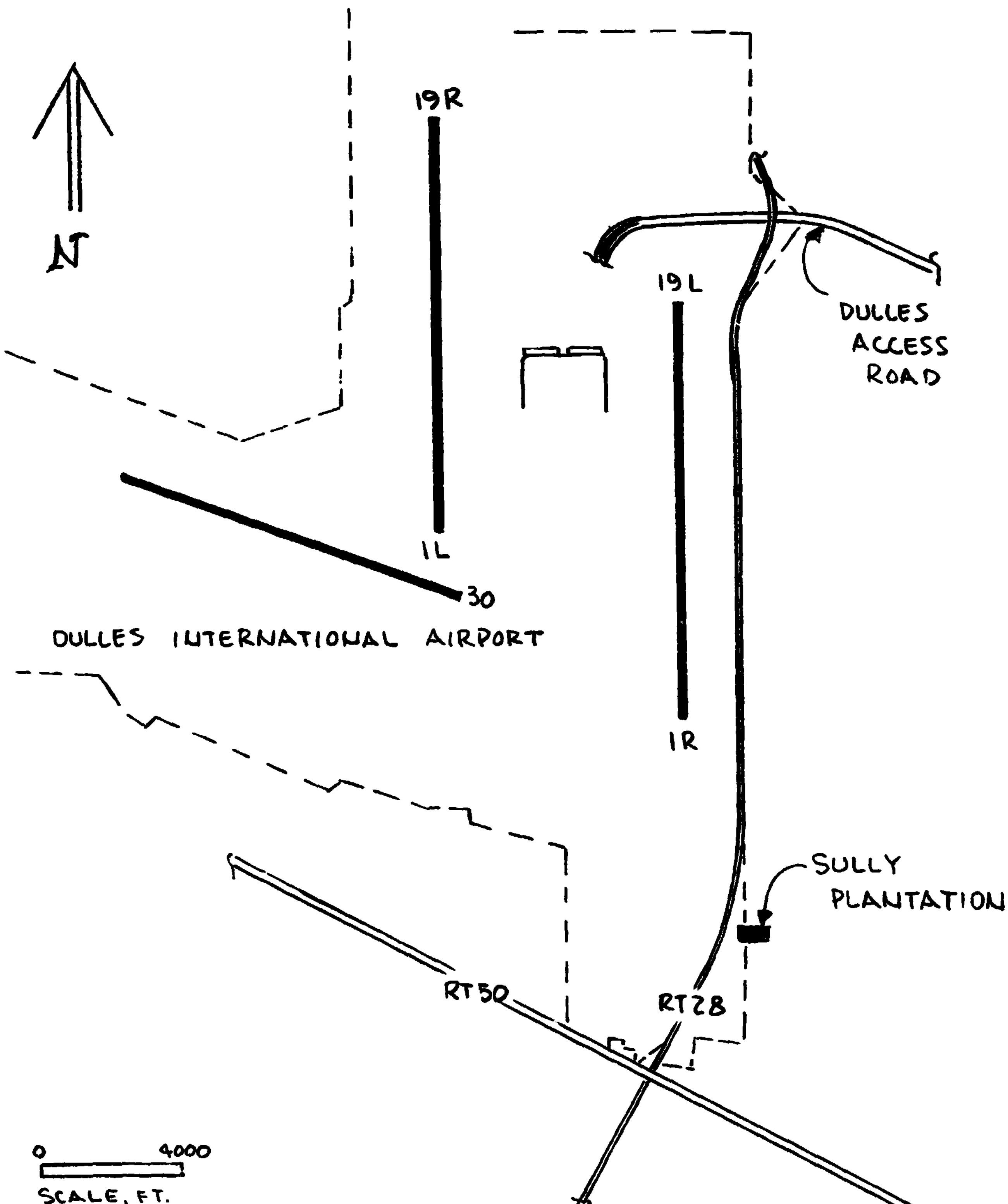

Figure 1.- Location of Sully Plantation

NASA
L-76-4231

Figure 2.- East elevation of Sully Plantation showing Concorde takeoff from 19L.

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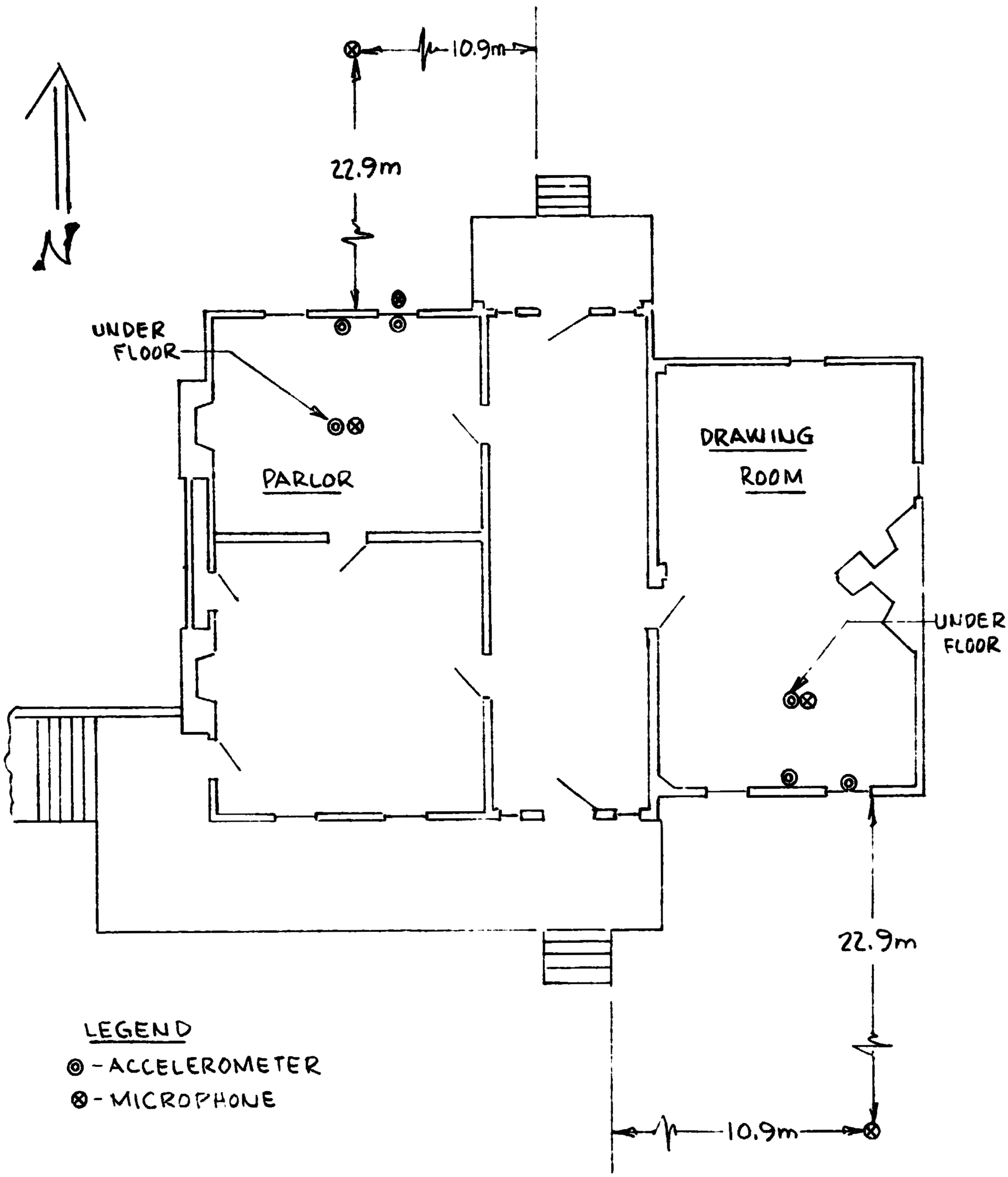

Figure 3.- First floor plan view showing transducer locations.

Figure 4.- Location of accelerometer for wall vibration measurements.

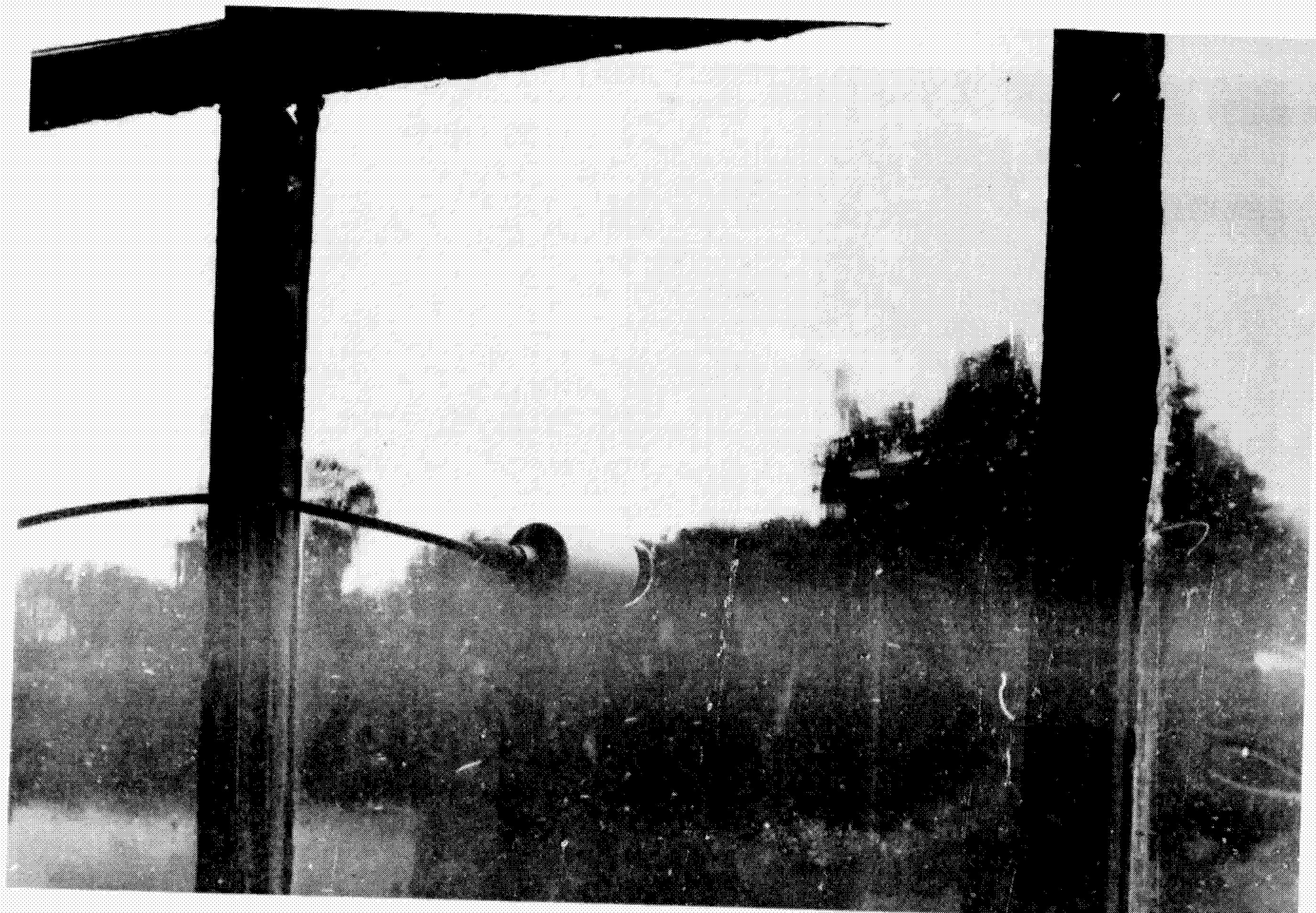

Figure 5.- Location of accelerometer for window vibration measurements.

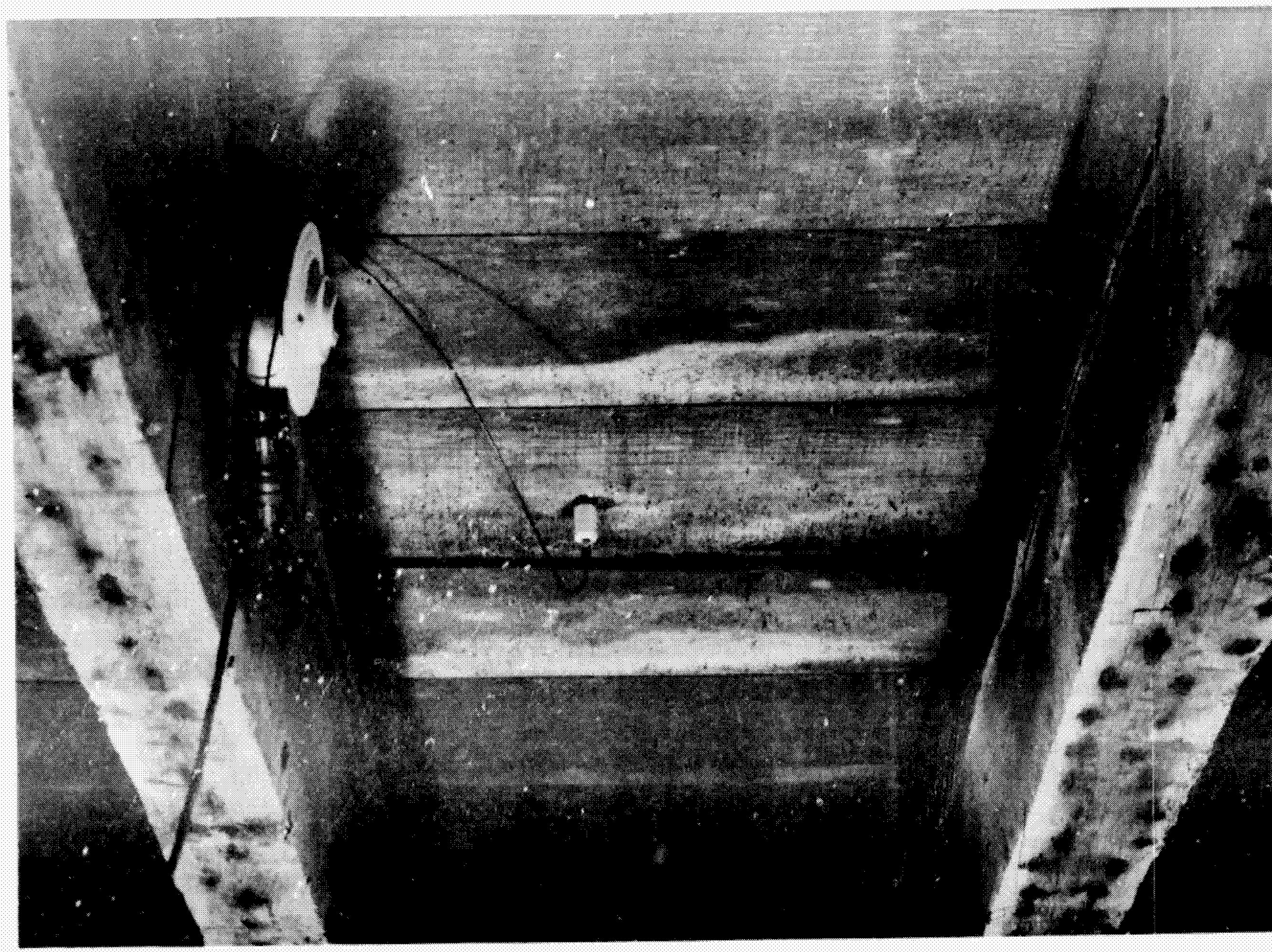

Figure 6.- Location of accelerometer for floor vibration measurements.

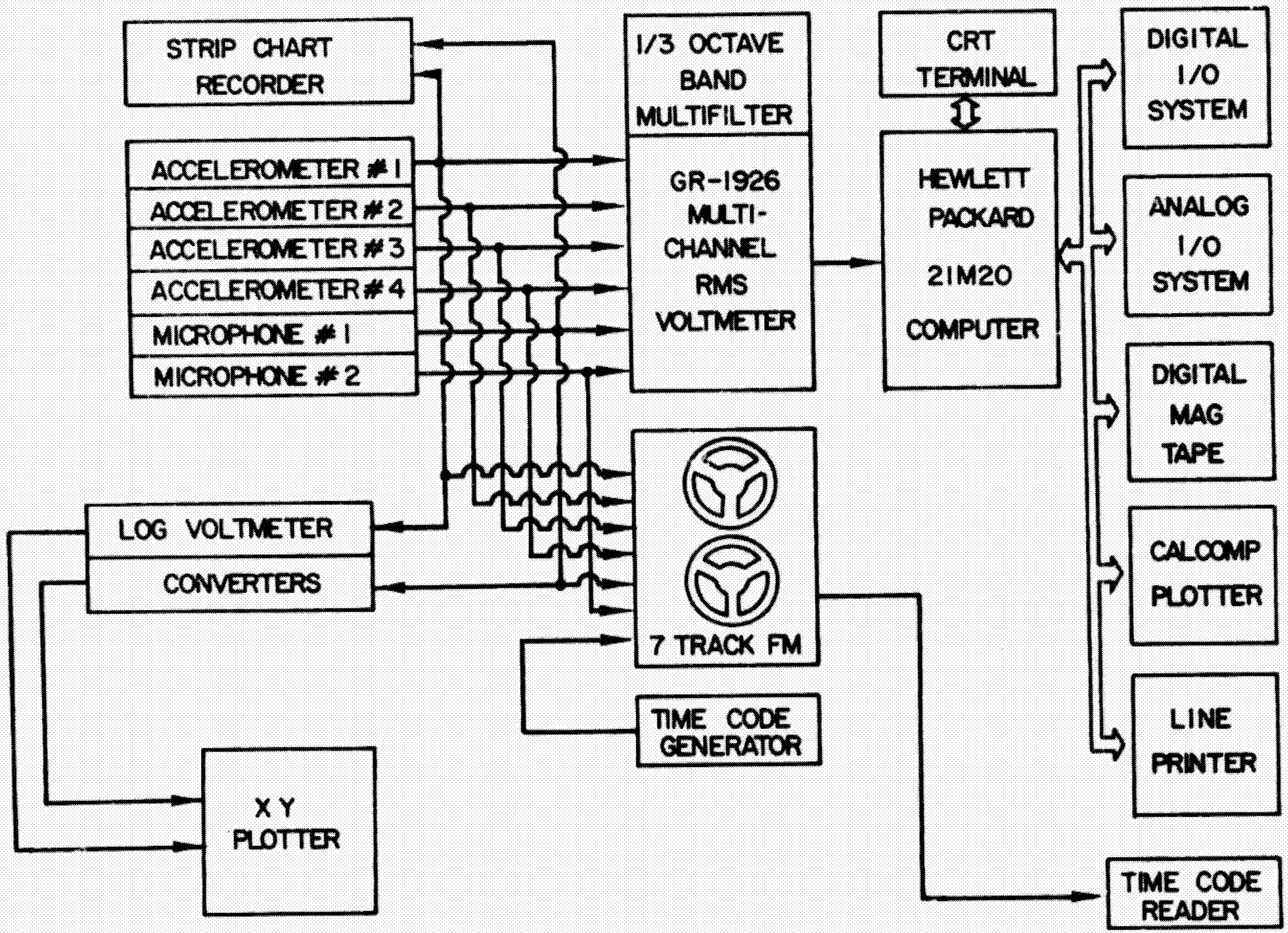

Figure 7.- Block diagrams of mobile data acquisition and processing system.

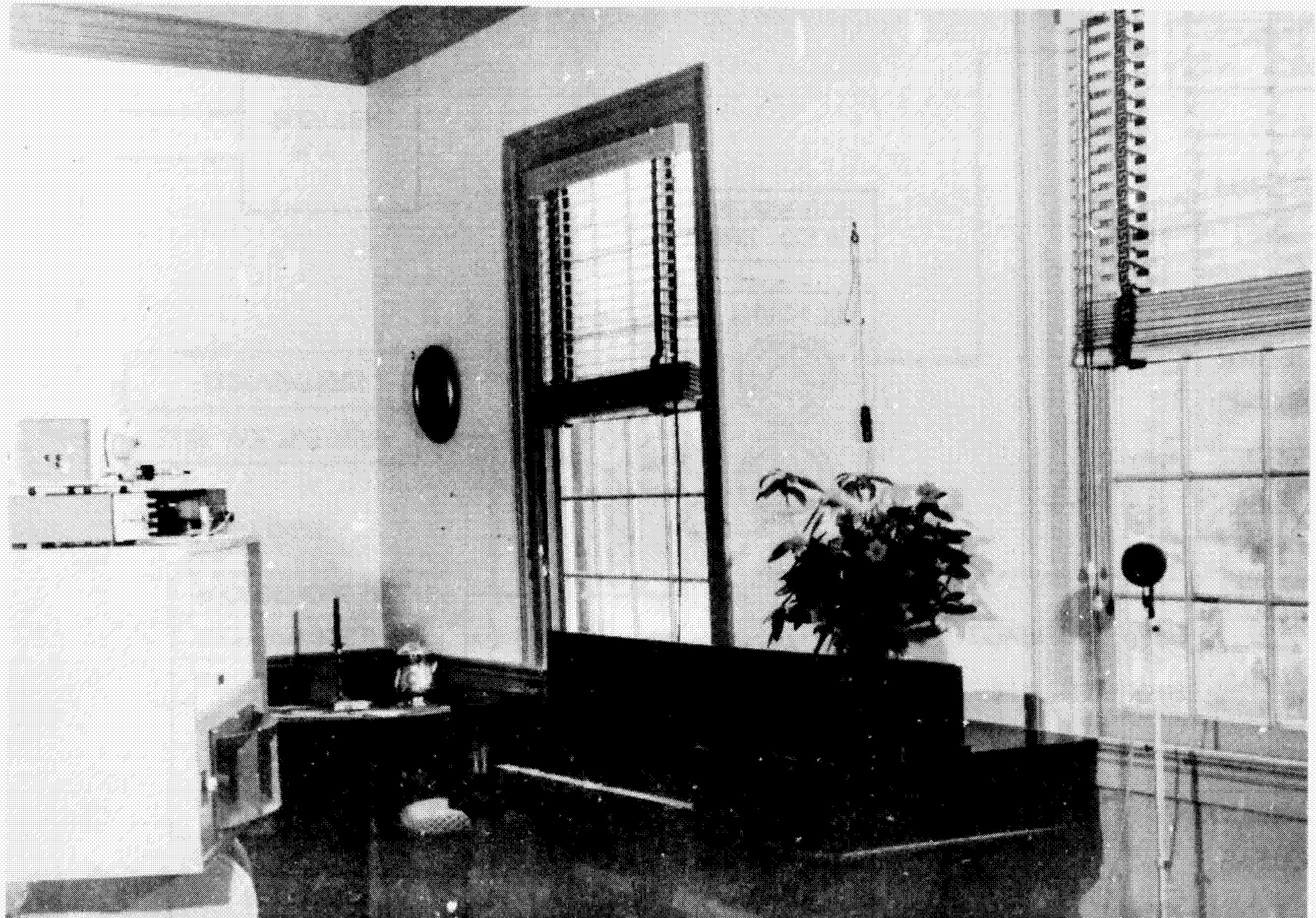

Figure 8.- Acoustic calibration.

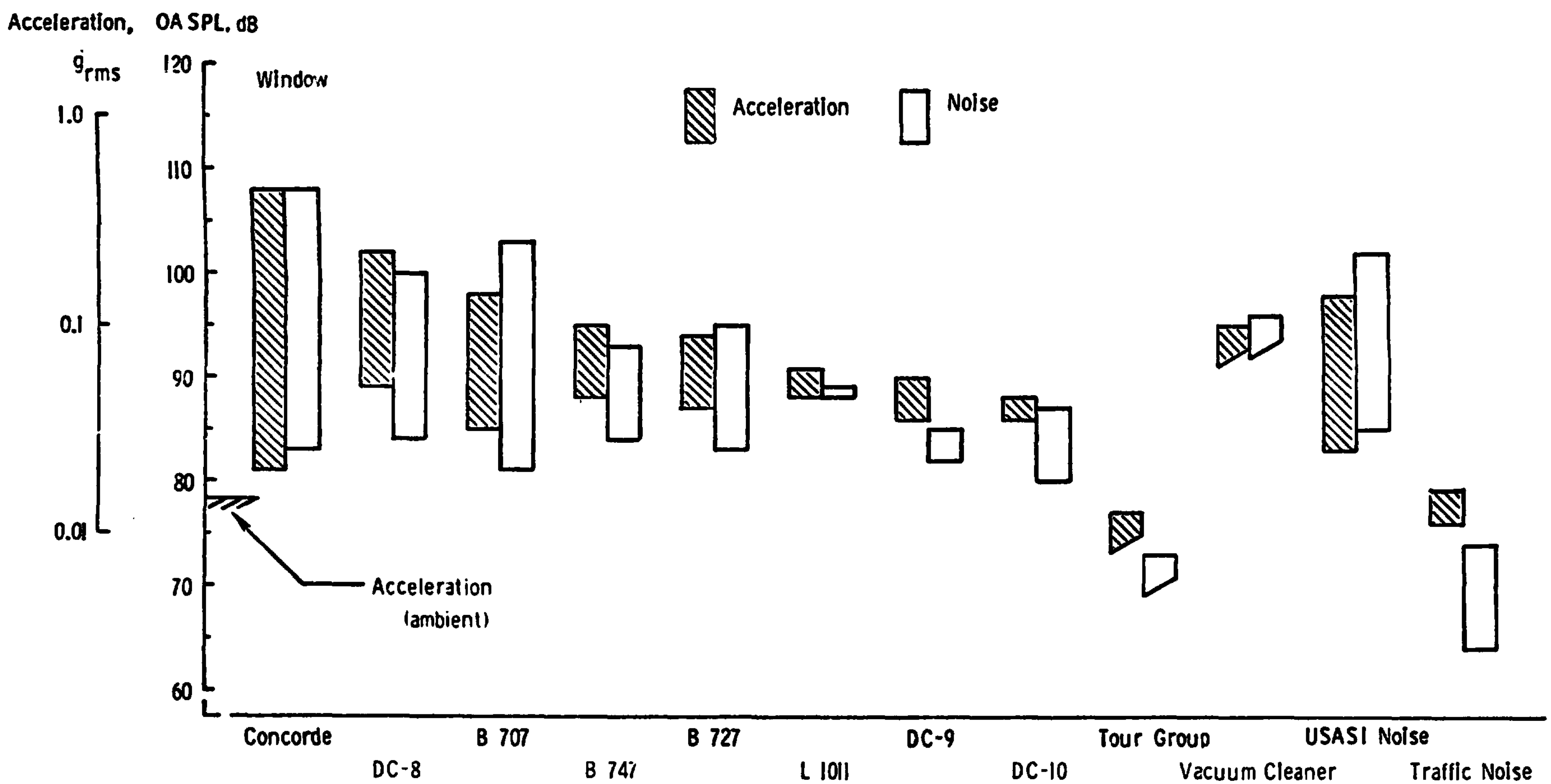

Figure 9.- Maximum levels of recorded vibration and noise for north window.

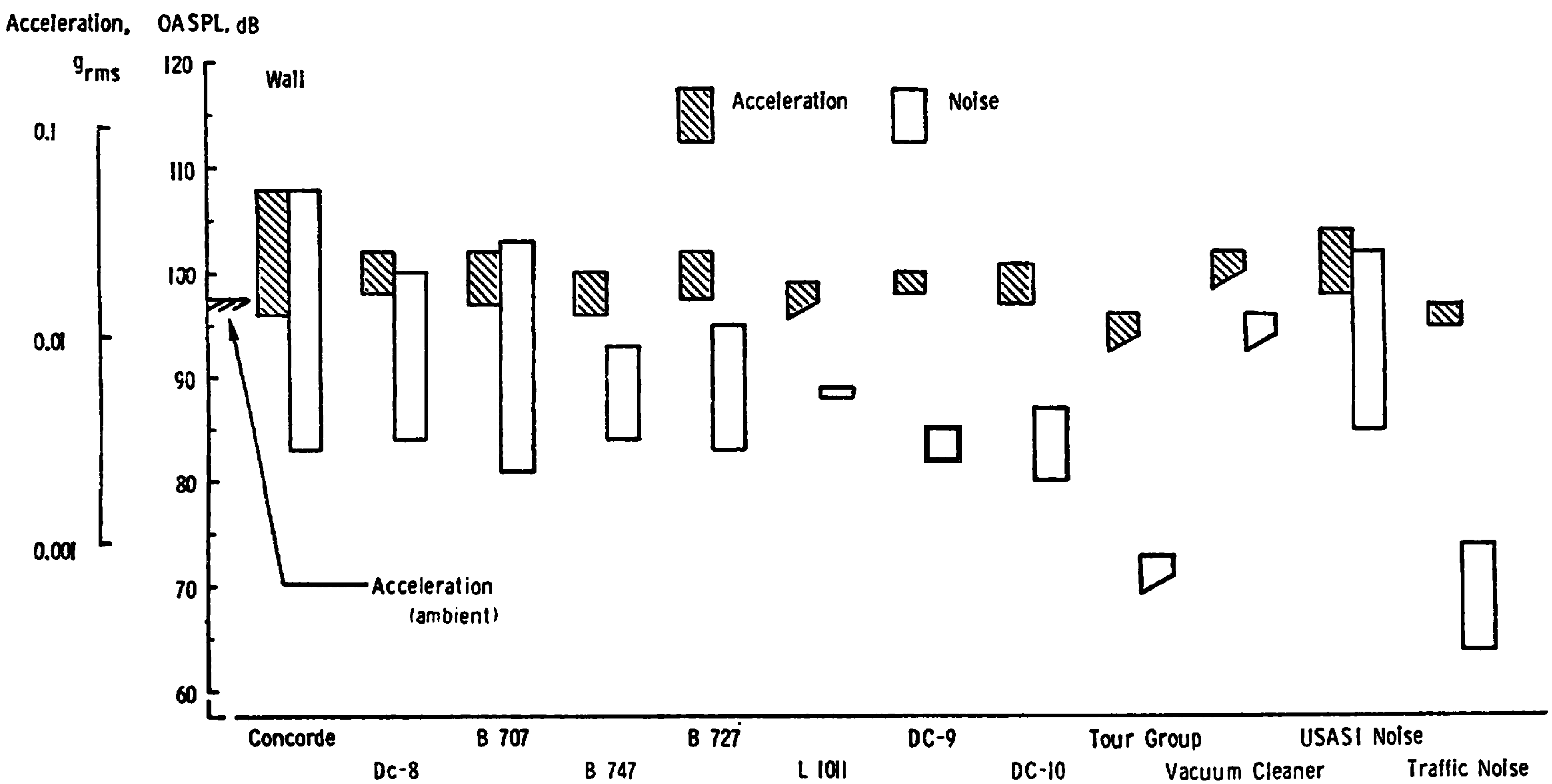

Figure 10.- Maximum levels of recorded vibration and noise for wall.

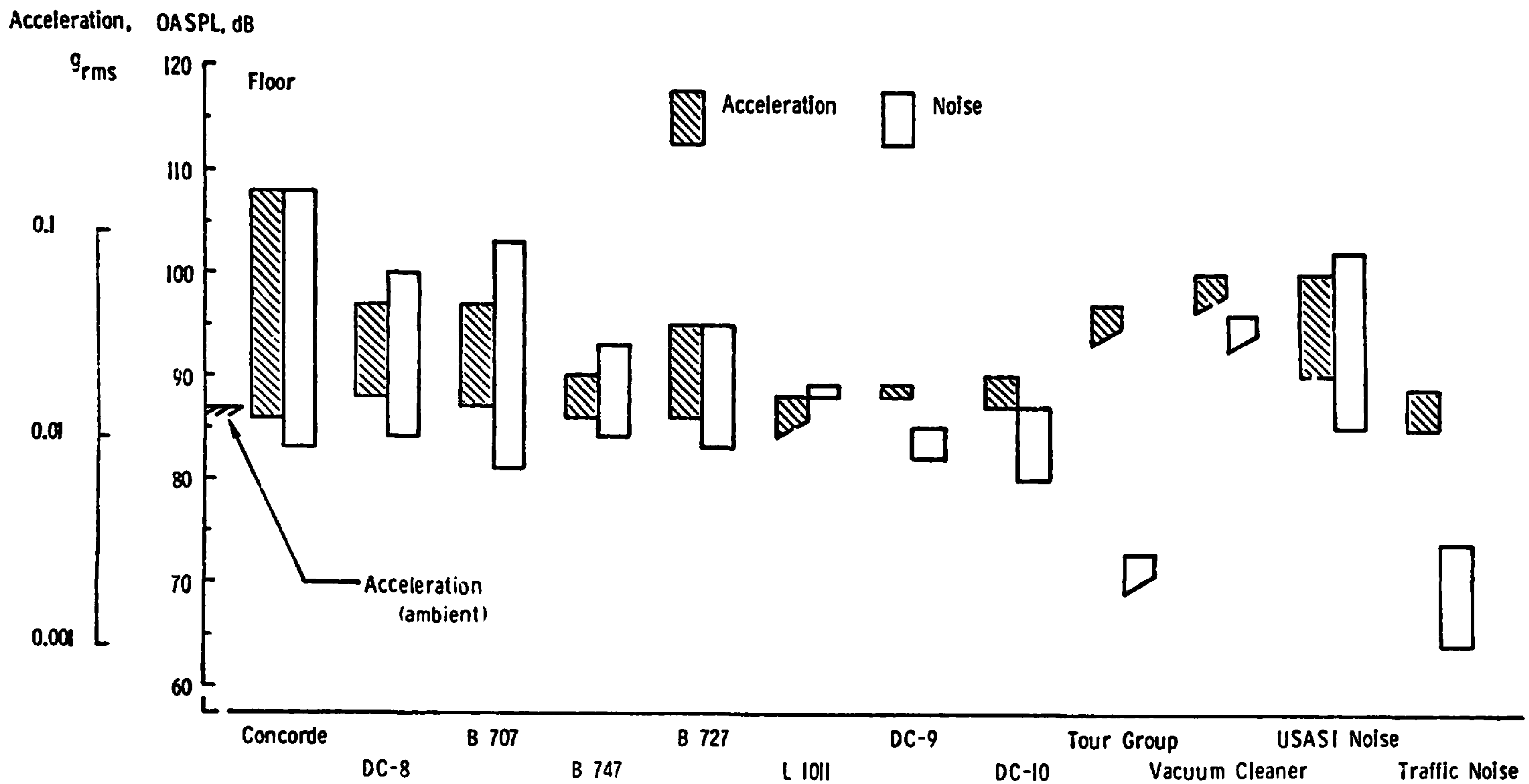

Figure 11.- Maximum levels of recorded vibration and noise for floor.

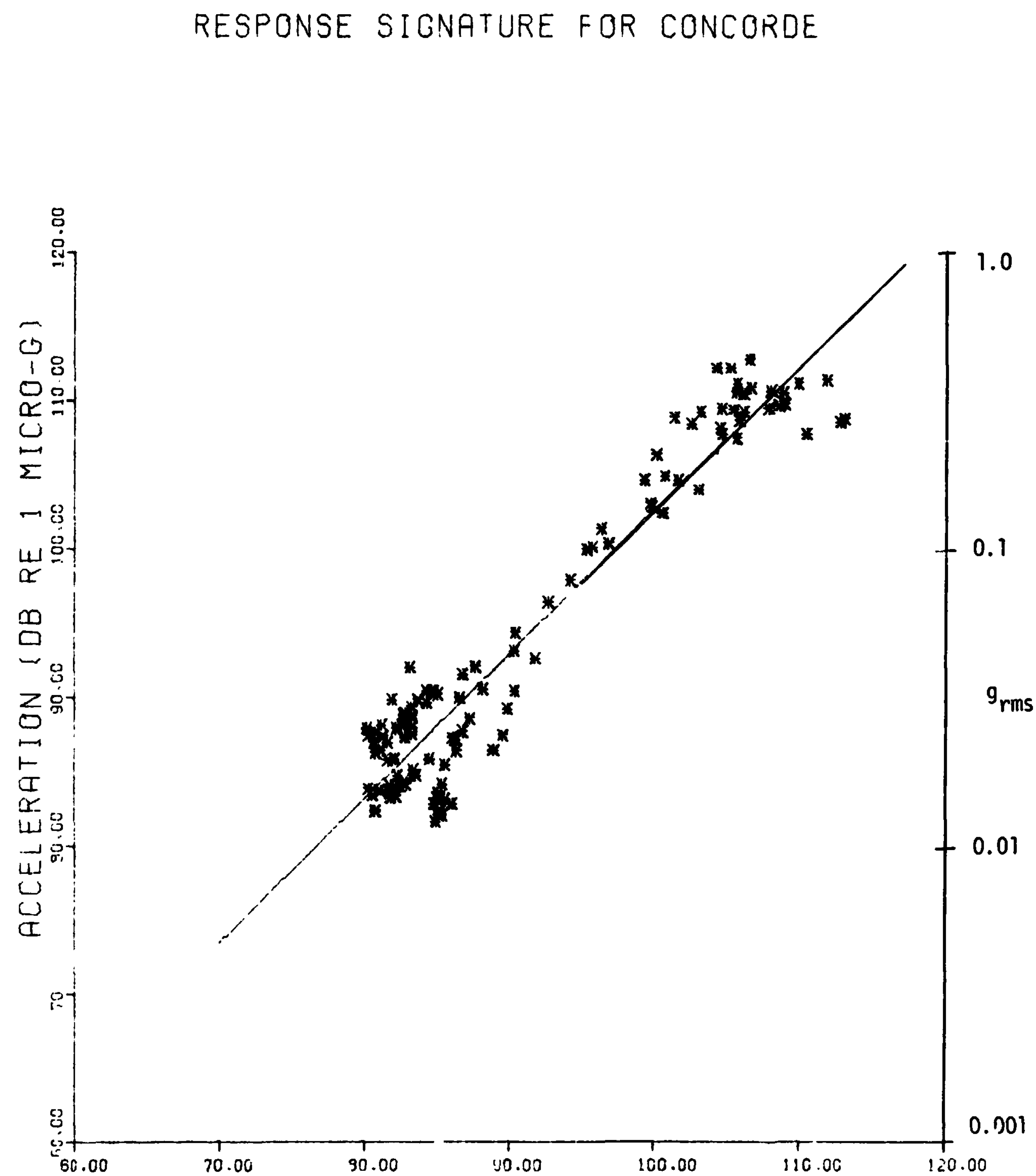

Figure 12.- North window vibration response for Concorde takeoff.

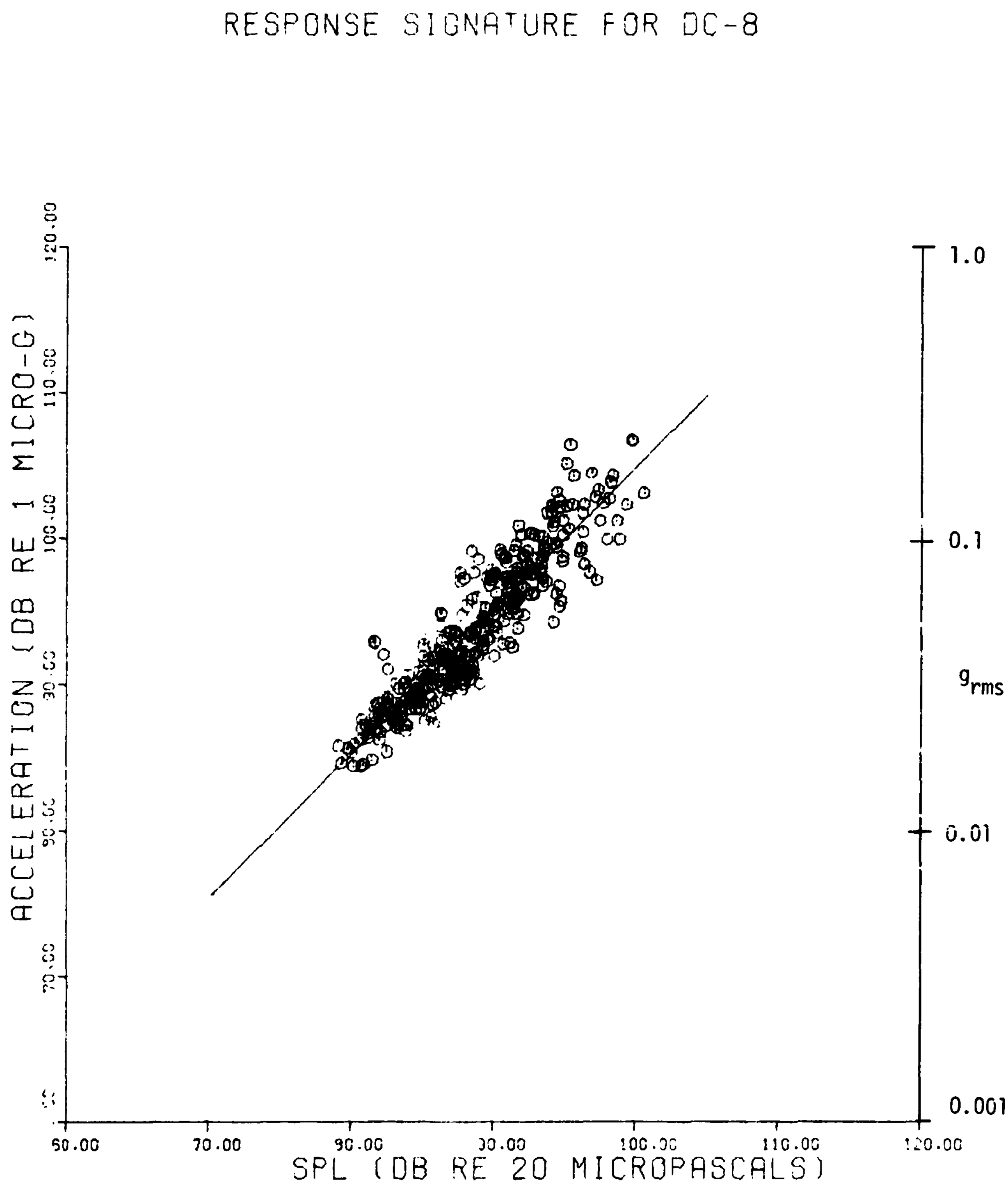

Figure 13.- North window vibration response for DC-8 takeoff.

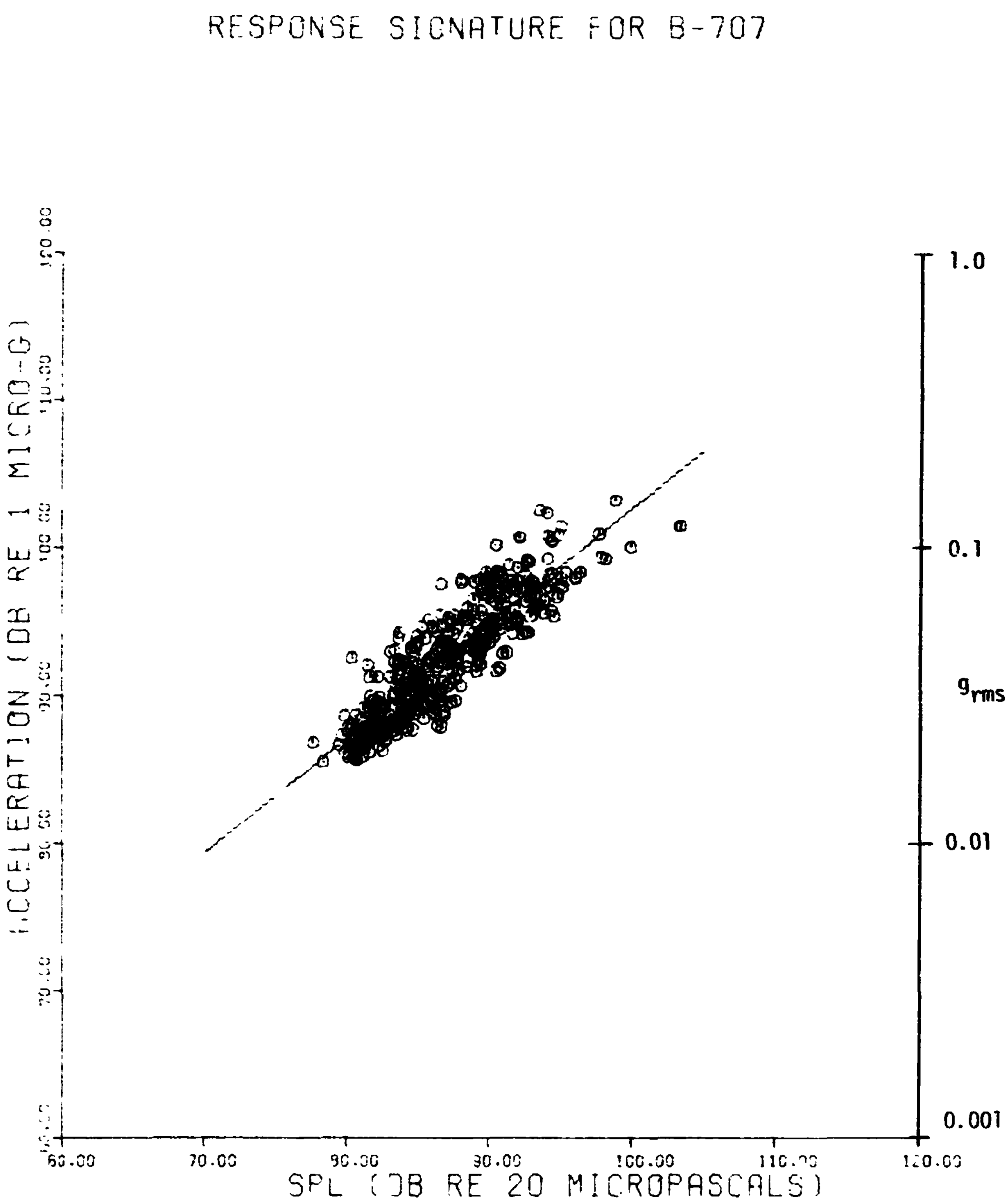

Figure 14.- North window vibration response for B-707 takeoff.

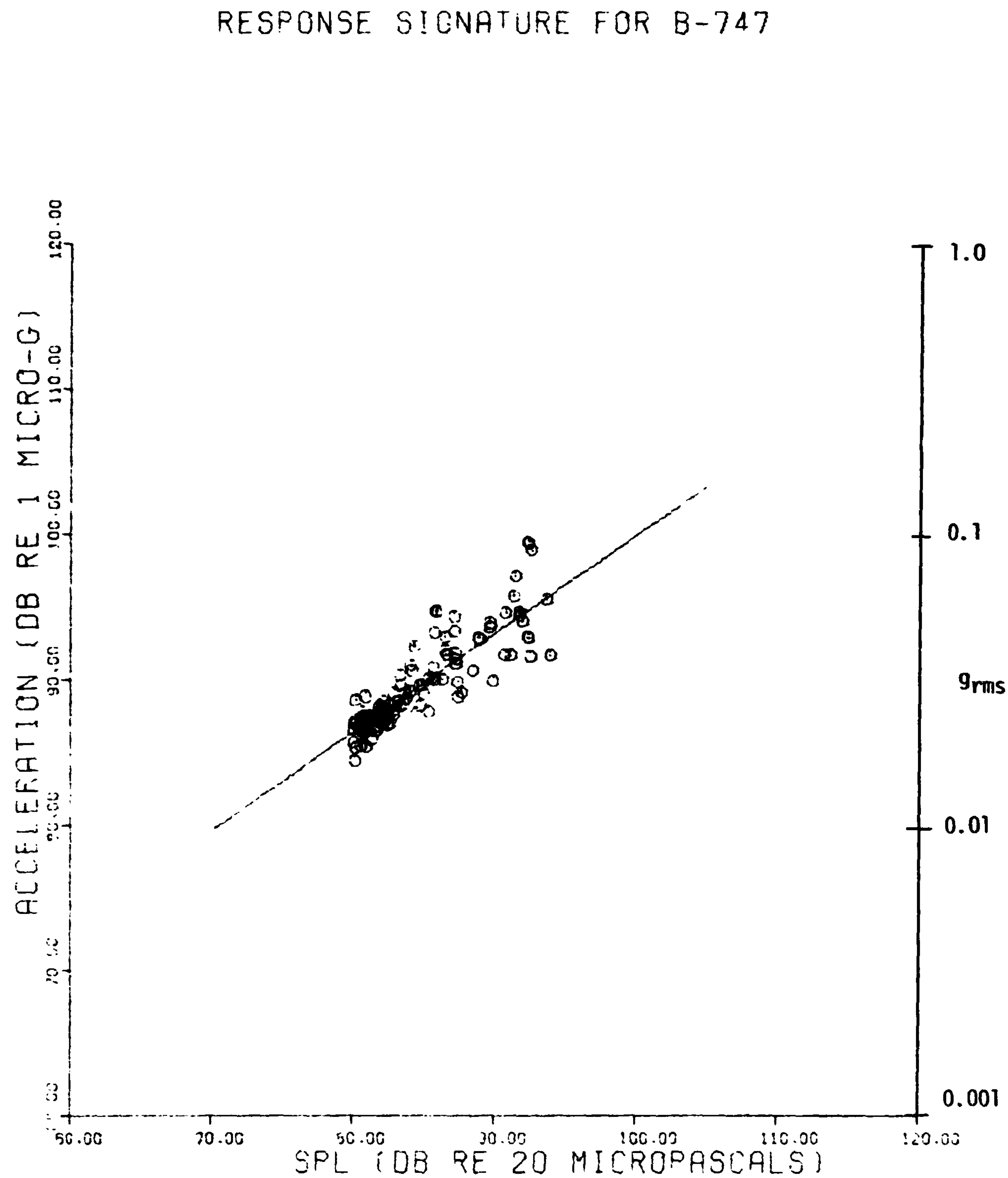

Figure 15. North window vibration response for B-747 takeoff.

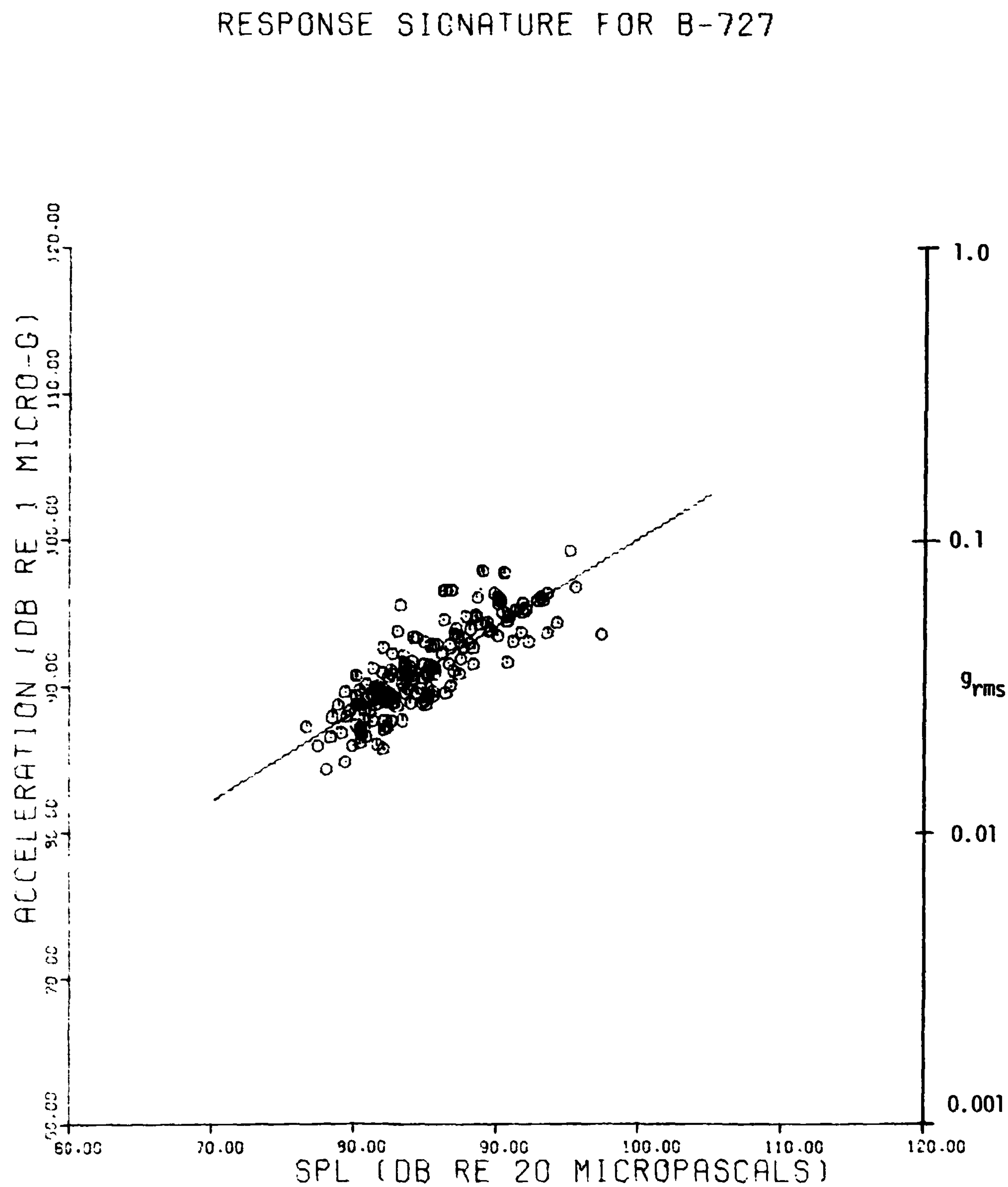

Figure 16.- North window vibration response for B-727 takeoff.

RESPONSE SIGNATURE FOR-CTOL COMPOSITE

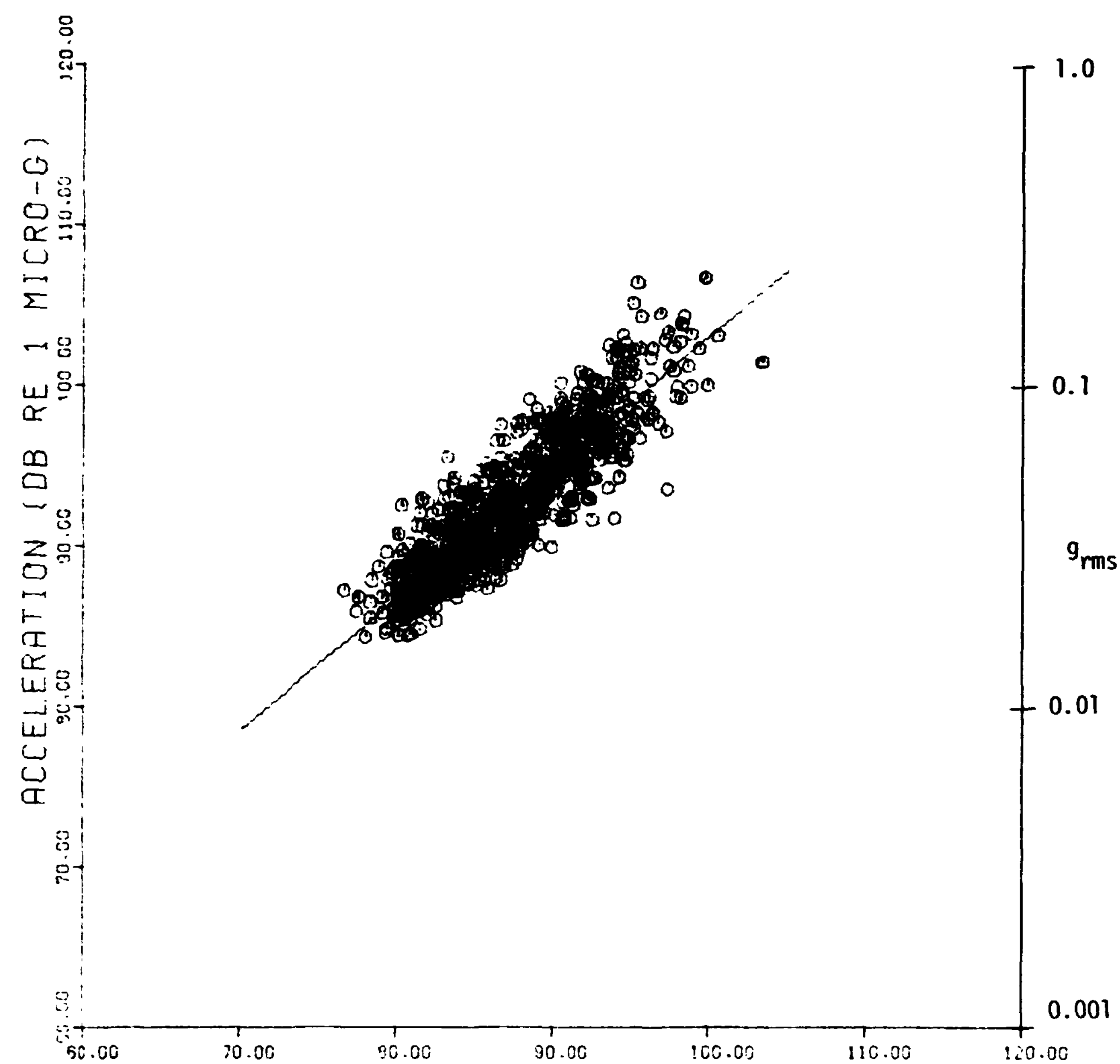

Figure 17.- North window vibration composite response for conventional aircraft takeoffs.

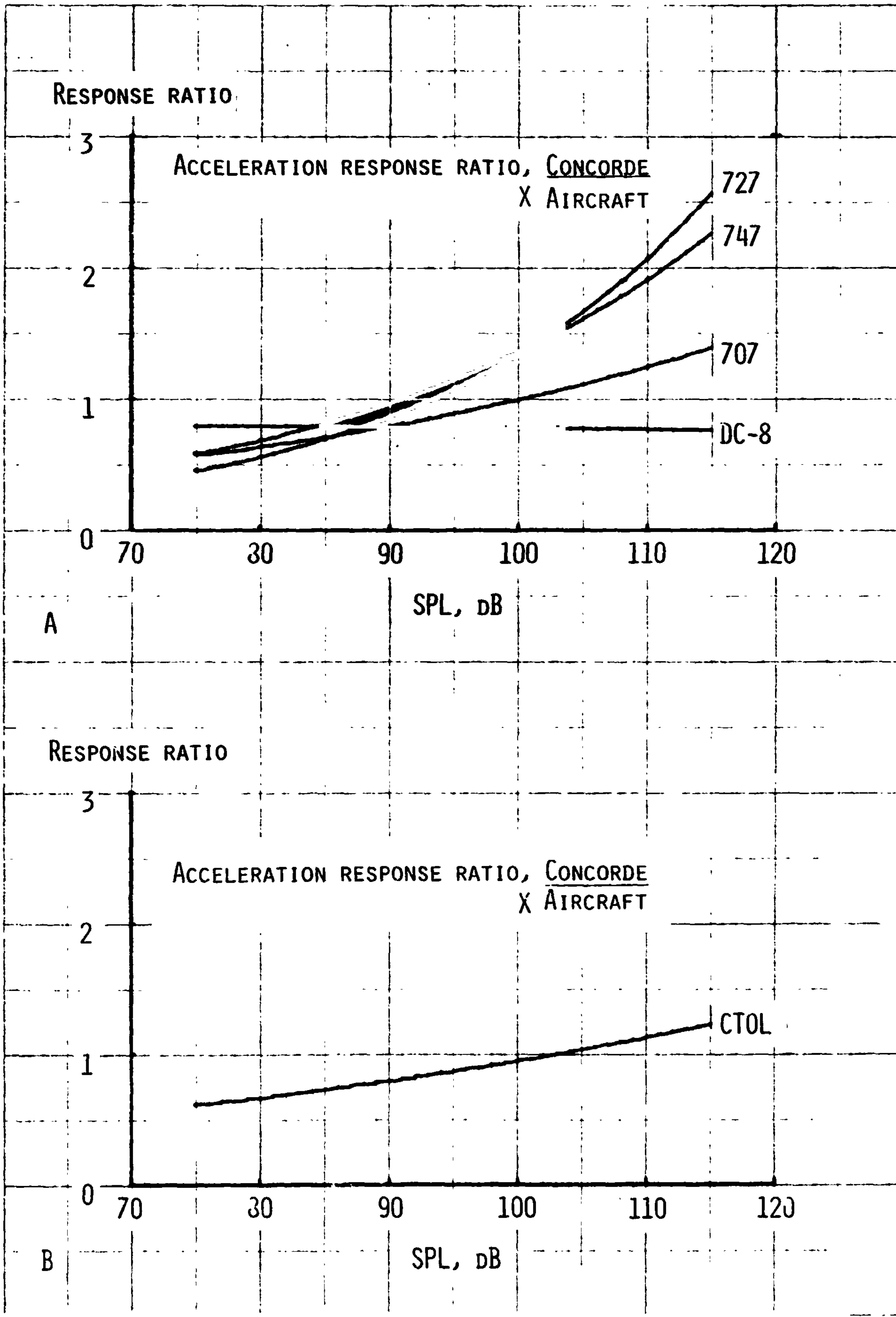

Figure 18.- North window vibration response ratio for Concorde and other aircraft during takeoff.